RELATION BETWEEN HEART RATE TURBULENCE AND HEART RATE VARIABILITY SPECTRAL COMPONENTS

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***Abstract*-It is generally accepted that HRV (heart rate variability) LF component frequency is related to the baroreflex control mechanism. In this study, HRV LF component and HRT (heart rate turbulence) spectrums are compared, and it is found that both have similar frequencies in a group of 33 subjects. It can be concluded that HRT mechanism is strongly influenced by the baroreflex system.**
Keywords-**Heart rate variability, Heart rate turbulence, Spectral Analysis, ECG signal processing**

I. INTRODUCTION

Heart rate turbulence (HRT) has been suggested as a new strong risk stratifier for cardiac patients. HRT has been shown to be independent from but additive to other mortality predictors such as left ventricular ejection fraction, arrhythmia signs, heart rate variability (HRV), and late potentials. [1]. The underlying mechanisms of heart rate turbulence have not yet been fully delineated. At present, the most likely mechanism is considered to be based on a baroreflex phenomenon [2]. If indeed a baroreflex based mechanism is involved, the frequency of oscillations in heart rate turbulence must coincide with the LF frequency of heart rate variability. A study performed by Schneider et. al. has focused on finding the power spectrum of HRT oscillations, and a single peak in the power spectrum at 0.1 Hz has been observed in a single patient[3]. This frequency is in the range of LF frequencies established in HRV studies [4]. However, a study comprising a large population of patients has not been performed. In this study, we obtained power spectrums of HRT and HRV in a group of 33 subjects in order to compare their peak frequencies.

II. METHODS

Holter recordings from 23 acute myocardial infarction patients and 10 controls obtained using ELA medical Holter system were processed. Data from patients were recorded during post-infarction hours.

Initial classification of heartbeats by ELA Medical Holter software were further edited and beats were classified as VPB (Ventricular Premature Beat), SVPB (Supraventricular Premature Beat), A (artifact), and N(Normal).

For each VPB occurrence, RR values for 5 beats preceding VPB, the VPB beat and 19 beats following VPB were taken as HRT tachogram. Each HRT tachogram was tested for suitability and, unsuitable HRT tachograms were eliminated. The test criteria for suitability were as follows [5]:

1. No R-R interval is shorter than 300 ms.
2. No R-R interval is longer than 2000 ms.
3. The difference between any RR interval and its preceding RR interval is less than 200 ms in absolute value.
4. The difference from the reference interval is shorter than 20%. The reference interval is the mean of the last 5 R-R intervals before the occurrence of VPB.
5. The pre-maturity is greater than 20%.
6. The post-extrasystole interval is at least 10% longer than the normal interval.

The average HRT tachogram for each patient was obtained by averaging the accepted HRT tachograms. Mean RR intervals before VPB are not the same for all tachograms from a patient. Therefore, averaging the HRT tachograms is equivalent to averaging signals with different sampling rates. To make the computations more precise and to establish a common time base, the HRT tachograms were interpolated to obtain values at fixed sampling times, i.e., RR values were obtained at fixed time instants for all tachograms. The sampling period in the interpolated data was taken as the mean five pre-VPB RR intervals of the uninterpolated average HRT tachogram. Each HRT tachogram was interpolated for a total time of 20 seconds following VPB. The interpolated HRT tachograms were averaged to obtain the average interpolated HRT tachogram for each patient.

An 8^{th} order AR model was fit to the average interpolated HRT tachogram using Yule-Walker method. Roots of the transfer function obtained were then computed. Imaginary parts of the roots were taken as the frequency components of the average HRT tachogram.

A suitable (smooth) segment of the RR time series is needed for HRV spectral analysis and comparisons with the HRT tachogram spectrum. From each patient, a 300 second-RR data segment was chosen for spectral analysis. The criteria for choosing the segment were as follows.

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
25OCT2001	N/A	-

Title and Subtitle Relation Between Heart Rate Turbulence and Heart Rate Variability Spectral Components	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Baskent University, Biomedical Engineering Department, Eskisehir Yolu 20.km 06530 Ankara/Turkey	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) US Army Research, Development and Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
Papers from the 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001 held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom., The original document contains color images.

Abstract

Subject Terms

Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU

Number of Pages
3

1. No R-R interval is shorter than 300 ms.
2. No R-R interval is longer than 2000 ms.
3. The difference between any RR interval and its preceding RR interval is less than 200 ms in absolute value.
4. No VPB or SVPB is observed.

Among the accepted smooth segments, the one, which has the smallest difference between its maximum and minimum values, was selected for spectral analysis. For HRV data, 20th order AR model was used.

III. RESULTS

In figures 1-5, results of analyses for one patient are shown. The average HRT tachogram for the patient is shown in Figure 1. This tachogram is the average of 64, 25-beat long uninterpolated HRT tachograms. Each of these 64 HRT tachograms was interpolated to obtain the interpolated tachograms sampled at every 0.84 seconds. This value is the mean of the pre-VPB heartbeat periods of the averaged HRT shown in Figure 1. The graph shown in Figure 2 is the average of post-VPB parts of the interpolated HRT tachograms. Occurrence of the second beat after VPB was taken as the time reference (0 sec.). Power spectrum of this signal, excluding the first two samples, is shown in Figure 3. The spectrum has a single peak at 0.0973 Hz. For all subjects, the first two samples of the averaged interpolated tachogram were excluded from spectral analysis because the actual starting instant of the baroreflex can be thought of as the beginning of the increase in RR intervals.

Figure 4 shows the smooth segment chosen from the same patient's RR data. The maximum heartbeat value is 895 ms. and the minimum value is 740 ms. Spectrum of the "smooth" segment is shown in Figure 5. The LF component frequency is 0.0995 Hz.

To compare the HRT and HRV frequency values for 10 controls, paired student-t test was applied. Mean value and variance of the HRV LF component frequency are 0.0802 Hz and 0.0001Hz^2 respectively. Corresponding values for HRT tachograms are 0.0774 Hz and 0.00006 Hz^2. P-one tail value is 0.258. Therefore, the null hypothesis, ´HRT and HRV spectrum frequencies are the same', is true at >0.1 significance level.

Similarly, HRT and HRV frequency values were compared for 23 patients. Mean value and variance of the HRV LF component frequency are 0.0857 Hz and 0.00024 Hz^2 respectively. Corresponding values for HRT tachograms are 0.0832 Hz and 0.00026 Hz^2. P-one tail value is 0.0899. Therefore, the null hypothesis, ´HRT and HRV spectrum frequencies are the same', is true at >0.05 significance level.

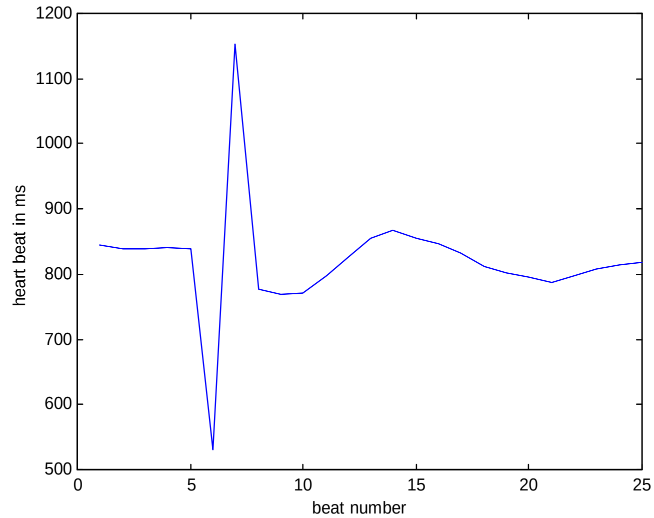

Figure 1: Average HRT tachogram

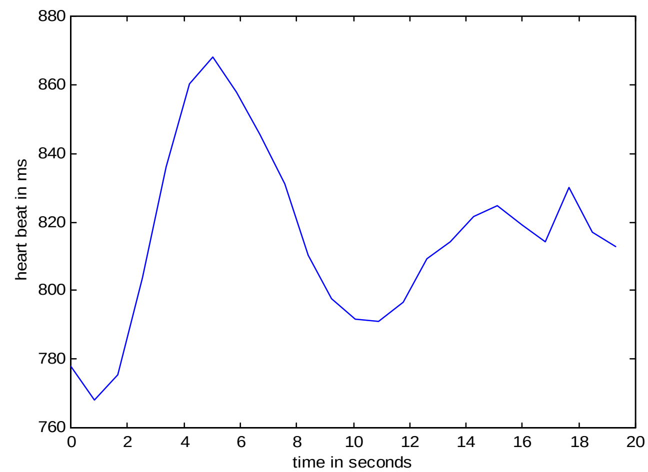

Figure-2: Post VPB part of average interpolated HRT tachogram

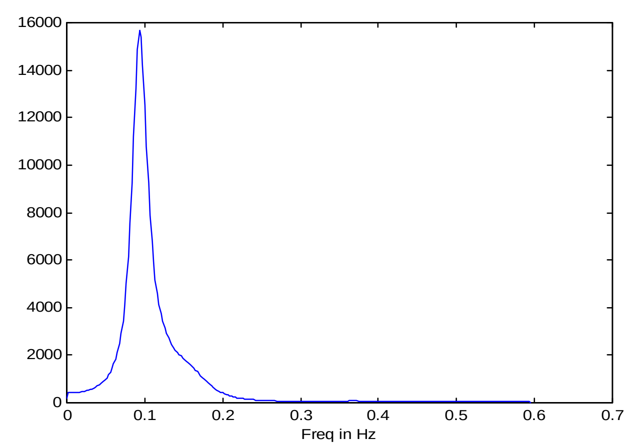

Figure-3: Frequency Spectrum of post-VPB part of average interpolated HRT tachogram

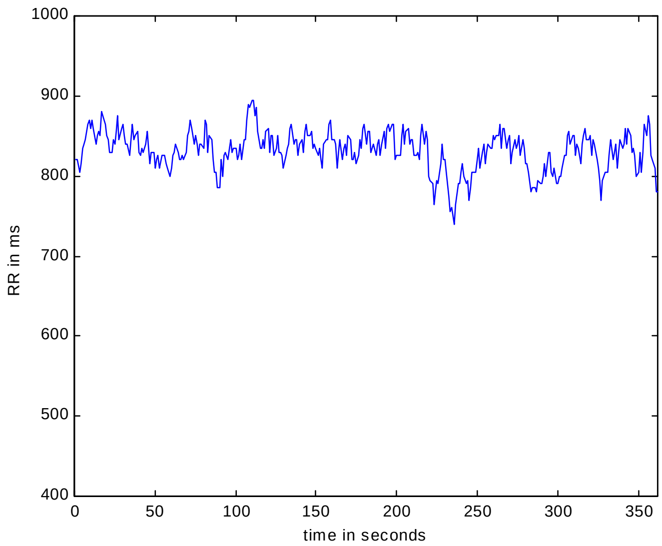

Figure-4 The selected “smooth” segment of RR data

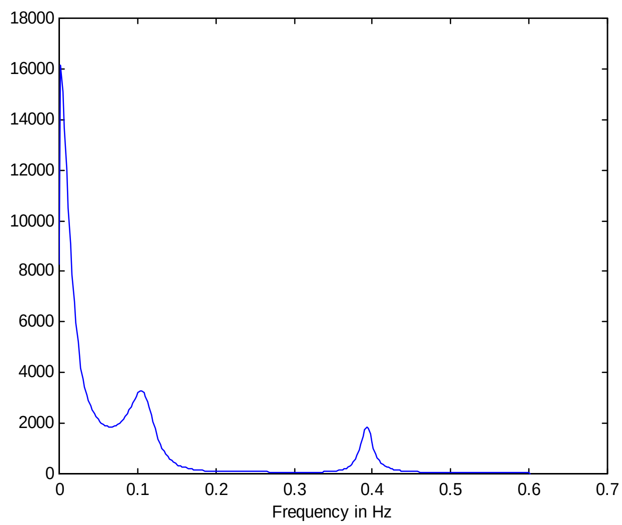

Figure-5: Frequency Spectrum of the selected “smooth” segment

IV. DISCUSSION

Results of this study show that HRV LF component frequency and the HRT frequency are very close to each other both in patients and controls. This finding supports very strongly the idea that HRT and HRV LF mechanisms are similar and presumably based on a baroreflex phenomenon.

Hacettepe University Cardiology Department and TEPA Inc. are involved in this study in relation to Euoreka Project Σ!2130-Dresh.

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